Explanation of Plate.

Fig. 1. Syncytium of growing amœbocytes.

Fig. 2. A type of mulberry corpuscle.

Fig. 3. Amœboid amœbocyte.

Fig. 4. Round amœbocyte.

Fig. 5. Minute amœbocyte.

Fig. 6. Cytoplasmic free cell.

Fig. 7. Degenerating amœbocyte with a few small, refractive crystals in cytoplasm.

Fig. 8. Degenerating amœboycte with numerous large, refractive crystals in cytoplasm.

Fig. 9. Disintegrated amœbocyte showing liberated granules and crystals.

Fig. 10. Double crystal formed by a normally disintegrating amœbocyte.

NOTES ON REARING INSECTS FOR EXPERIMENTAL PURPOSES AND LIFE-HISTORY WORK.[1]

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Introduction.

During the past two years I have been rearing insects for experimental and life-history studies. While engaged in this work it became necessary to develop new rearing methods and to modify some of the old ones.

The rearing of insects from egg to adult is not always an easy task. Unforeseen difficulties arise anew with every species, in consequence of which I am offering these notes with the hope that entomologists will find them serviceable.

During the life history of insects reared artificially, the following must be observed:

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1. Provision for an abundance of normal food.
2. Provision for a suitable larval environment.
3. Provision for a suitable pupal environment.
4. Provision for a suitable adult and egg laying environment.
5. Regulation of temperature and humidity.
6. Prevention of disease.
7. Prevention of parasitism by other insects.

The Use of Fruit Jars with Tin Covers.

The general use of shallow fruit jars (Pl. II, fig. 1) has been found extremely successful for many species of insects. By altering conditions slightly for each stage (egg, larval, pupal and adult), these jars can be used throughout the life of many forms. The jars are four inches deep and four inches in diameter. The tin tops can be screwed on tightly without the use of rubber bands. Insects confined in these jars cannot escape, nor can parasites enter.

It is easy to duplicate conditions required by insects fond of a moist environment or which pupate in the soil. If at any time an excess of moisture forms, it may be diminished by loosening the screw tops or by adding a small quantity of dry sand.

The following constitutes the method used successfully for rearing lepidopterous larvæ:

Care of the Eggs.

The eggs are placed in a jar containing a piece of filter or blotting paper to absorb the excess moisture. The cover is screwed on tightly to prevent any larvæ from escaping when they hatch. Once in every three or four days, the cover is removed for a moment to permit the circulation of air.

Care of the Larvæ.

As soon as hatching commences, a small amount of food is placed in the jars. Several hundred caterpillars may be placed in one jar, but as they increase in size the number per jar should be decreased in order to prevent overcrowding. After the larvæ have molted once or twice, the filter paper may be removed, and a fourth of an inch of dry sand substituted. The sand is changed every three or four days before it becomes foul or mold develops. The jars should be kept shaded to ensure a nearly even temperature.

Care of the Pupæ.

As soon as the larvæ have pupated, the jars are cleaned and moist sand is put in. When moistening the sand, just enough water is added to darken it. The covers are screwed down tightly, but are removed every few days to allow a circulation of fresh air. If the sand becomes too moist, the covers are loosened; if too dry, a few drops of water may be added.

Care of the Adults.

Before emergence, some bits of coarse hay, dry moss or pieces of paper are inserted into the jars to provide a resting place for the adults as soon as they appear. If perfect specimens of large species are desired the lidless jars are placed in a large wooden or pasteboard box. A stiff piece of paper or cardboard is inserted into each jar so the adults may easily crawl out. This arrangement will provide sufficient room for them to expand their wings and dry perfectly.

Mating the Adults.

Some species of insects mate in almost any situation, but the majority prefer a simulation of their natural environment. These conditions may be provided in a number of ways. One of the most satisfactory methods is to grow the food plant of the species of insect concerned in a box of soil. When matings are desired, a small cylindrical wire screen or lamp chimney is placed over some of the food and the males and females placed thereon. When it is necessary for the adults to feed before mating, sugar-water may be provided. The mating cages should be shaded and left undisturbed until after the deposition of the eggs.

Hibernating Pupæ.

The fruit jars have been used with great success in caring for hibernating pupæ. Species that normally hibernate in the soil are placed in jars filled nearly half full of moist sand. This moisture will ensure sufficient humidity for several weeks. The jars should be opened every week or two to allow a circulation of fresh air. This also assists in the prevention of mold development. Jars with hibernating pupæ have been kept in a greenhouse where the temperature ranged from 60° to 80° F. during the day and from 45° to 55° F. at night with success. The jars should be shaded.

Fruit Jars for Rearing Borers.

The jars may be used successfully for rearing borers from twigs, rotten wood, bark and fungi. Moist sand should not be added in this case, otherwise mold will develop.

Fruit Jars with Cheese-cloth Tops.

The jars may be used with cheese-cloth covers especially during damp or rainy weather. Such covers have disadvantages compared with the tin tops. Much time is consumed in tying on the cheese-cloth, or if rubber bands are used, they are apt to break and allow the insects to escape. In dry weather the food does not remain fresh by the use of the cheese-cloth tops.

Other Methods.

Caterpillars Reared in Bulk.

If several hundred larvæ of a species, that normally pupate in the soil, are to be reared together, the following method has proven successful:

A pen or corral was made of sheet tin or zinc. This was placed in the soil to a depth of two inches, while the upper edges were tanglefooted or the top covered with cheese-cloth. The tanglefoot prevents the larvæ from crawling out, but cheese-cloth is at times preferable if parasites are abundant.

The mortality from wilt and other diseases is generally quite high in this type of rearing cage because the crowding aids the spread of infection.

Tin Boxes.

Isolated material is often desired, especially in experimental studies. For this work, I make use of small tin boxes with tightly fitting covers, one inch deep and two and a half inches in diameter. These boxes take up very little space, are easily cleaned by boiling in water or by sterilizing, and can be used repeatedly. They prevent parasites from entering and the larvæ seem not to suffer in the least from the confinement. If the boxes are shaded the food keeps fresh for several days or until eaten.

When the larvæ are nearly ready to pupate, a little sand is placed in the boxes. Moisture emitted by the food and larvæ is generally sufficient, but a few drops of water may be added to the sand when needed.

Battery Jars.

Battery jars (Pl. III, fig. 1) with pieces of glass for covers have been quite useful for rearing some insects. The glass covers ensure a high humidity and this naturally keeps the food fresh. Such jars were found to be very satisfactory for rearing silkworms, many hundred having been reared during the summers of 1915 and 1916.

Sand was placed in the bottom of the jars. During damp weather, or when there was an excess of water of condensation, the covers were removed to facilitate evaporation. Silkworms, as is known, do not ordinarily leave their food, so the covers could be removed with impunity.

For rearing wood-boring insects, the battery jars have also been found very useful.

Trays.

Several types of trays, designed at the Gipsy Moth Laboratory at Melrose Highlands, Mass., have been used quite extensively in rearing gipsy moths during the past few years. I have used trays of various sizes and shapes. The trays (Pl. III, fig. 2) were usually made entirely of cardboard or wood with cheese-cloth or paraffin paper bottoms. To prevent larvæ from escaping, the edges of the trays were smeared with tangle-foot. These trays are used extensively, but when a large number of larvæ are reared in a single tray, some difficulty is experienced, for the larvæ often get caught in the tangle-foot and eventually form a bridge over which others escape. The tangle-foot must be repeatedly combed or stirred with a stiff brush. This cleans the tangle-foot and also forms ridges over which it is difficult for the larvæ to escape.

Diseases frequently develop and the mortality is generally high in such trays.

Riley Cages.

I have used a modified type of the Riley cage built for the Gipsy Moth Laboratory, with considerable success. The frames are built of wood, covered with a fine wire mesh. They are provided with removable wooden bottoms and have a door on one side. The cages are sixteen inches square and twenty-four inches in height.

Considerable material, especially Cerambycids and their para-

sites, have been reared in these cages, from dead wood, etc. The cages were kept in a green-house, in a shaded position, and the wood containing the insects was moistened about once a week.

The cages have also been utilized to some extent for rearing army-worms out of doors. In this case the bottoms were removed and the cages set in soil in a shaded place. If only a small number of larvæ are to be reared, the cages may be placed over the insects' natural food plant, but if one is dealing with great numbers, the food must be renewed daily. The cages are also useful in making matings. Some trouble was experienced by the swelling or shrinking of the cage doors, depending on weather conditions.

Test Tubes.

For rearing fruit-flies of the genus Drosophila, test tubes (Pl. II, fig. 2) have proven very successful. An artificial food, banana agar, was used. This was made by crushing four ripe bananas and allowing them to infuse in 500 cc. of distilled water. The liquid was strained and $7\frac{1}{2}$ grams of powdered agar added. The whole was then cooked until the agar was dissolved. The mixture was poured into test tubes, after which the tubes were sterilized and permitted to cool in a slanting position. Non-absorbent cotton plugs were used. The flies will readily oviposit on this medium and many generations a year may be reared. A piece of filter paper was placed in the tubes for the maggots to pupate upon. Fresh tubes are used for each generation. When newly hatched flies are to be transferred, they are first stupefied with ether.

The banana agar is nearly transparent which enables one to note the feeding habits, etc., of the larvæ.

Explanation of Plates II and III.

Plate II, Fig. 1. Fruit jars used for rearing various insects.

Plate II, Fig. 2. Test tubes used for rearing flies of the genus Drosophila.

Plate III, Fig. 1. Battery jars used for rearing various insects.

Plate III, Fig. 2. Tray with paraffin paper bottom, for rearing insects.